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MOMENTUM IN VARIATION.

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EVER since the theory of evolution was grounded and the fact that each form and species is the result of accumulated variations from a less specialized ancestor, was established, this same variation has been scrutinized to find its causes and laws. Darwin made it more or less sporadic, and saw in the struggle for existence the factor which selected the useful variations and eliminated the less suitable innovations. Later, recognizing many features, especially ornamental characters, as not useful, he also proposed sexual selection as a second factor in determining the preservation of variations. Others, especially paleontologists, have been struck by the fact that variations are in a line, so that useful features develop rapidly; and second, by the frequency with which several lines of variation appear in a form practically simultaneously, all in conformity to the particular habitat and habit of the possessor. Further, remarkable convergences are found in animals of different groups when placed in the same habitat. These facts lead to two lines of thought: first, that the environment acts on the animal more than merely to select such variations as chance may offer; and second, that the animal in its life, by its habits, acquires characters which are handed to its offspring accentuated, and thus adaptive features are rapidly developed.

In the above an explanation is found for the development of useful characters, but there remain still two classes to be accounted for. First, those which in their early stages are of no account, but when developed become important (as the cusps on teeth); and second those which have developed to perform a useful function but in later forms have reached a degree of specialization which has proved either a hindrance or the destruction of the possessor. To this class also belong those features developed to a degree of perfection beyond the requirements of utility (sponge spicules, Radiolarian shells, some plant blossoms).

For instance in the early members of the family of saber-toothed tigers (Machærodidæ), the upper canine teeth are elongated and flattened, making in such forms as Dinictis and Hoplophoneus a most efficient weapon. However, the elongating went on gradually until in a form like Smilodon the great tushes reach far below the lower jaw, and to open the mouth wide enough to take in food below the weapons was practically impossible, so that most of the food probably went in between the canines. At this stage the family, world wide in its distribution, died out.

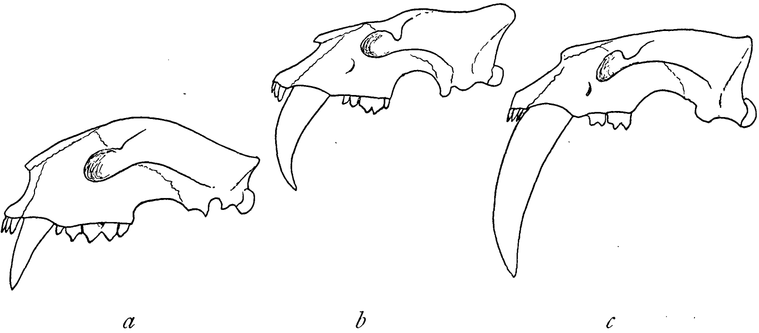

FIG. 1. — Series of saber-toothed tigers' crania. *a*, Dinictis ; *b*, Hoplophoneus ; *c*, Smilodon.

Taking this as an illustration of a variation going beyond its utility, there seems to the writer to be but one adequate explanation, namely, that as a special feature develops it attains a momentum which tends to carry it beyond the point of greatest utility. In so doing it may become a hindrance even to the point of exterminating its possessor, or may merely attain a perfection, not detrimental, but without other explanation.

Let this be applied to various groups. In the Radiolarian shell enough symmetry to maintain the balance of the animal would be expected, but when a mathematical perfection is shown in the repetition of every spine and ray in marvelous complexity, something more than utility has been subserved. The same may be said of the flesh spicules of sponges. At first being merely a deposition of something spinous in the flesh, so as to be disagreeable enough to protect the sponge from being eaten by small animals, these spicules are later carried to the perfection of symmetry. These, with the symmetry of sessile crinoids, sea anemones, and floating jelly-fishes offer illustrations of the carrying of a feature far beyond utility, toward perfect symmetry.

The molluscan Hippurites starts as a form which thickens its shells, one of them especially, apparently as a protective measure. But when the shell has reached a thickness of an inch it can hardly be considered useful to increase it further. However, these forms go on increasing in thickness to in some cases over a foot, using up the vitality which would otherwise be available for reproduction. Momentum seems to be the only reasonable explanation in such cases, and there are several (Coralliopsidæ, Gryphea, Caprinidæ, etc.).

Among Cephalopoda the complication of the edge of the septum of various Ammonites offers another case. A sinuous margin is doubtless a better brace against the pressure of the outside sea water, and such an irregular line as that of Goniatites or even Medliocottia (see Fig. 2) would be interpreted as useful. However, when it is carried to the complication found in Desmoceras or Pinacoceras, only momentum seems to explain the condition.

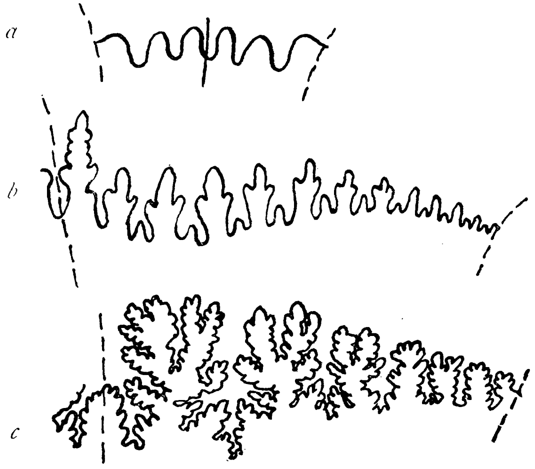

FIG. 2. — Series showing suture lines of Ammonites. *a*, Goniatites; *b*, Medliocottia; *c*, Desmoceras.

Turning to the vertebrates where the balance required for survival is even more delicate, the tooth of the Labyrinthodonts is another instance. Here the surface is at first infolded probably for greater strength, but this is carried to a degree so complex as to be a puzzle to work out. Among the reptiles the Stegosaurian family adopted a dermal armor which some members developed till the double dorsal row of plates set on edge consisted of pieces some of which are over three feet across and several inches thick at the base. With such an excessive load of bony weight entailing a drain on vitality, it is little wonder that the family was short-lived. Doubtless the elongation of the snout was useful to the forms ancestral to Teleosaurus, but carried to the excess found in that genus, it resulted in a weak grasp, and the form disappeared.

Among the mammals the saber-toothed tigers have been mentioned. The mammoth with its extreme development of tusks may also serve to illustrate the principle. For, while at first the moderate tusk is an efficient weapon, as soon as it begins to be recurved as in *Elephas primigenius*, it loses its defensive value, and the carrying of the great weight is a drain on the vitality. A better example is seen in Babirusa where the canine teeth at first developed to protrude outward and of utility in digging, have gradually curved up over the snout, and appear more like horns than teeth. As they are now and were for a considerable portion of their previous development, they must be a serious hindrance in feeding.

The horns of many forms have also developed beyond usefulness. Take for instance those of the elk and moose, where if useful it is only in conflicts with other males once a year. But their great spread is a constant menace, requiring care lest in running they come to trees not far enough apart to admit of going between. Then the drain on the animal which sheds these great bony growths annually and replaces them again, is great. It is only as the result of momentum that these cases seem reasonable.

Among sheep where excessively heavy horns, such as those of the Kamchatka sheep and the big-horn, are developed, the great weight which lends force in butting can hardly be considered to offset the disadvantage which they entail in climbing and running. Wherever horns have been developed there seems to be this tendency to carry them to excess, as in Titanotheres, Tinoceras, Elasmotheres, Irish elk, etc.

The above are selected examples in which a feature once useful has been developed beyond its maximum utility. Many others equally striking might be cited, the explanation of all of which is extremely difficult unless such a factor as momentum is called in. In the light of this factor, however, a logical and apparent cause is found. Momentum also explains why a character that originated in accordance with the environment develops so rapidly, and why, when an animal had reached adjustment to its surroundings, it still goes on beyond a perfect adjustment. It may be laid down as a rule then that *a variation started along any line tends to carry that line of development to its ultimate, being driven by momentum.* If the feature is detrimental the group dies out ; if, however, it is merely a minor feature it makes a handicap. A line of development may be stopped and its momentum overcome but the tendency is to keep right on.

This factor of momentum has not been given the importance due it, although it is felt in the undercurrent of the thought of several authors. It is the writer's belief, however, that it should find an important place in the explanation of animal structures.

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